STRUCTURAL DESIGN OF A MULTI-LEVEL CIVIL ENGINEERING BUILDING WITH BASEMENT PARKING AND GYMNASIUM AT LA CONCEPCION COLLEGE, KAYPIAN

An Experimental Research

Presented to the Faculty of Civil Engineering Division

La Concepcion College

In Partial Fulfilment of the Requirements for the Degree

Bachelor of Science in Civil Engineering

Major in Construction Engineering

and Management

Russel Christian R. Blasco

Jewel C. Candaza

Danna Daisy M. Malasmas

Jenice N. Rubis

2026

RECOMMENDATION

This is to certify that this research entitled **"STRUCTURAL DESIGN OF A MULTI-LEVEL CIVIL ENGINEERING BUILDING WITH BASEMENT PARKING AND GYMNASIUM AT LA CONCEPCION COLLEGE, KAYPIAN,"** prepared and submitted by Russel Christian R. Blasco, Jewel C. Candaza, Danna Daisy M. Malasmas, and Jenice N. Rubis have been examined and PASSED the PRE – ORAL DEFENSE.

ENGR. ELOISA P. CADAG, Reg. CE., MACT
Research Adviser

PANEL OF EXAMINERS

Examined and approved by the Panel of Examiners in a Pre - Oral Defense with a grade of_____on November_____ 2025, at La Concepcion College, Bulacan.

Engr. DANILO A. CASAS, LPT, MAEd
Chairman

Engr. CAROLINE A. ASUNCION
Member

Engr. CAMILO A. BATULAN JR., MSCM
Member

Accepted as partial fulfilment of the requirements for the degree of Bachelor of Science in Civil Engineering.

JORE GIL D. GALEZA
Division Head of Civil Engineering

DR. LEILANI I. CUSACK, DBA
Dean of Instruction

CERTIFICATE OF ORIGINALITY

This certificate hereby verifies that this was originally made by the researchers and that no research has been previously written or published by another person or organization, not even any awards and recognition materials from other colleges and universities or other tertiary learning institutions have been asserted hereto, except where due acknowledgment is made thereof.

Furthermore, we declare that the intellectual content of this research is the product of our thorough endeavors by harnessing group's fresh ideas, and utilizing simple language and style as can be observed in the manner of our representation.

Russel Christian R. Blasco
Jewel C. Candaza
Danna Daisy M. Malasmas
Jenice N. Rubis

Attested by:

Engr. Eloisa P. Cadag, Reg. CE., MACT
Research Adviser
Date: _____

TABLE OF CONTENTS

Page

TITLE PAGE i

RECOMMENDATION ii

CERTIFICATE OF ORIGINALITY iii

CHAPTER 1 ..... **1**

The Problem and Its Background *1*

Introduction 1

Background of the Study 2

Theoretical Framework 4

IPO Conceptual Framework 5

Statement of the Problem 8

Objective of the Study 9

Hypothesis 11

Significance of the Study 12

Scope and Limitation of the Study 13

Definition of Terms 14

CHAPTER 2 ……**16**

Review of Related Literature and Studies.....*16*

Foreign Literature.....16

Local Literature.....18

Foreign Study.....21

Local Study.....23

Synthesis of Review in Related Literature and Studies.....25

CHAPTER 3.....**27**

Research Methodology.....*27*

Research Design.....27

Research Instrument.....29

Designing.....29

Surveys.....30

STAAD AND SAP2000.....30

Miniature Model.....30

Data Gathering Procedure.....30

Statistical Tool.....31

CHAPTER 1

The Problem and Its Background

This chapter presents the overview of the study including the introduction, background of the study, theoretical framework, statement of the problem, hypothesis, scope and limitations of the study, significance of the study, and definition of terms.

Introduction

The learning environment is essential in supporting the academic needs of students and the teaching responsibilities of faculty. In the field of Civil Engineering, the quality and design of educational buildings are particularly important, as they directly affect safety, accessibility, and the overall effectiveness of academic activities. A well-designed facility ensures that learning takes place in an environment that is functional, secure, and supportive of academic growth.

In response to the growing academic and developmental needs of La Concepcion College in Kaypian, San Jose del Monte, Bulacan, this study focuses on the structural design of a proposed multi-level Civil Engineering building. The structure is intended to serve as a facility for Civil Engineering students, providing classrooms, laboratories, faculty spaces, and a gymnasium to support both academic and physical development. The addition of basement parking aims to improve campus accessibility and maximize the use of available spaces.

With the rising need for modern, functional, and safe academic facilities, structural design is essential to ensure that the building is practical, reliable and compliant with current engineering standards. This project will include detailed structural planning, analysis, and design, following the National Structural Code of the Philippines (NSCP) and other relevant codes and guidelines.

Currently, La Concepcion College is experiencing challenges due to limited classroom spaces and facilities that are no longer sufficient to meet the growing academic demands of its students. These circumstances emphasize the necessity of constructing a well-planned Civil Engineering building that can address these limitations and provide a more suitable environment for learning and development.

Background of the study

The growing demand for Civil Engineering education shows the need for facilities that support both classroom learning and practical training. This field requires not only rooms for lectures but also laboratories and special areas for hand-on activities. Without these, students may find it hard to build the skills they need, and teachers may struggle to give effective instruction.

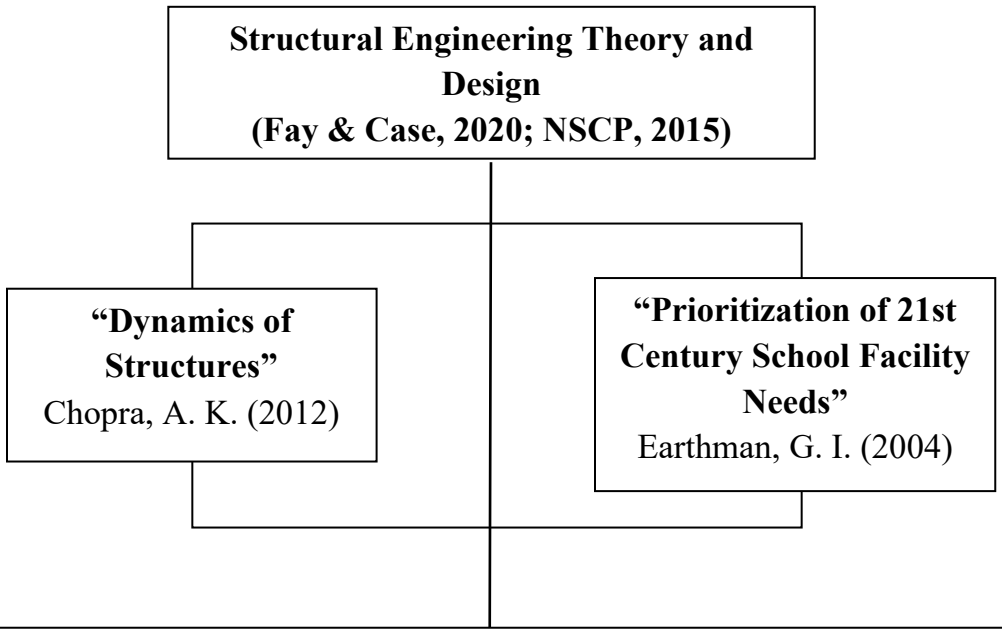
Many Institutions continue to face problems such as a lack of classrooms, limited laboratory spaces, and outdated facilities. For instance, a study at the Palompon Institute of Technology revealed deficiencies in laboratory equipment and resources, limiting students' access to proper training (Mangompit, 2022). Likewise, at Cochin University of Science and Technology (CUSAT), the rapid expansion of programs without sufficient infrastructure resulted in classroom shortages and overcrowding

(Times of India, 2023). These cases show that the lack of adequate facilities is a persistent issue in civil engineering education.

The need for a new location for the Civil Engineering department is clear. Student enrolment is increasing, and the curriculum is expanding to require more specialized facilities. However, there are not enough classrooms and laboratories to provide effective hands-on learning experience for civil engineering students. To address these problems, multi-story buildings have been proposed. This facility envisioned to meet both educational and development needs by including multiple floors for academic and administrative functions, a gymnasium to support health and wellness, and a basement parking area to maximize campus space and improve accessibility.

This study will provide a detailed structural design for the proposed building. It will examine structural components, choose suitable materials for construction, and ensure safe occupancy while meeting seismic and environmental requirements. The project is aligned with the National Structural Code of the Philippines (NSCP) and other relevant standards to ensure safety, stability, and durability. In the long term, this proposed facility aims to support the vision of La Concepcion College by creating a strong, functional, and future-ready educational environment.

Theoretical Framework


Structural Engineering Theory and Design
(Fay & Case, 2020; NSCP, 2015)
"Dynamics of Structures"
Chopra, A. K. (2012)
"Prioritization of 21st Century School Facility Needs"
Earthman, G. I. (2004)

The theoretical framework of this study is based on the principles presented by Fay and Case (2020) in Structural Engineering Theory and Design, which provide a comprehensive foundation for analyzing and designing safe, stable, and code-compliant multi-level structures in line with the National Structural Code of the Philippines (NSCP, 2015). Supporting this is Chopra's (2012) Dynamics of Structures, which introduces performance-based design concepts that help ensure the structure can respond effectively to real-world conditions such as seismic activity and varying loads. Additionally, Earthman's (2004) Prioritization of 21st Century School Facility Needs emphasizes the importance of creating learning environments that are accessible, functional, and conducive to academic performance. Together, these studies support the development of a Civil Engineering building that is structurally sound, responsive to environmental demands, and supportive of

Figure 1: *The theoretical framework illustrates theories from different studies.*

IPO Conceptual Framework

INPUT	PROCESS	OUTPUT
1. How can the proposed structural system sustain the maximum load capacity considering dead load, live load, wind load, and seismic load in terms of: 1.1 Compliance with the National Structural Code of the Philippines (NSCP) 1.2 Stability and factor of safety of beams, columns, slabs, and foundations 1.3 Overall resistance against structural failure 2. How can the durability and service life of the building materials and structural system be determined in terms of: 2.1 Resistance to deterioration under environmental exposure 2.2 Structural performance during seismic conditions 2.3 Estimated lifespan of the materials used	● Perform structural analysis following NSCP load combinations to ensure stability, safety, and resistance against failure ● Design structural system to ensure safety, stability, and durability based on analysis result ● Evaluate material performance under environmental and seismic condition to estimate lifespan ● Plan the basement parking layout based on standards, circulation flow, accessibility, and safety features ● Prepare layouts that meet space standards while ensuring comfort,	

3. How can the basement parking facility be designed in terms of: 3.1 Vehicle capacity based on standard parking dimensions 3.2 Circulation flow and accessibility for users 3.3 Safety and security provisions for vehicles and pedestrians 4. How can the allocation of usable floor areas for classrooms, laboratories, and faculty rooms be optimized in terms of: 4.1 Total floor area provided versus required standards 4.2 Comfort and functionality of spaces for learning 4.3 Effective utilization of the available building footprint 5. How can the gymnasium design support institutional activities in terms of: 5.1 Maximum occupancy capacity for academic and recreational functions 5.2 Suitability for sports and student wellness programs	functionality, and efficient footprint use ● Design gymnasium to support academic, recreational, and institutional activities ● Assess overall design in terms of accessibility, safety, and functionality, and convenience for the Civil Engineering department ● Prepare architectural floor plans and layouts using AutoCAD to define spaces for classrooms, laboratories, faculty rooms, gymnasium, and basement parking ● Prepare a detailed cost estimate covering materials, labor, and provisions to determine financial feasibility	

5.3 Accommodation of large-scale school events 6. How can the overall proposed structural design contribute to the Civil Engineering department's development in terms of: 6.1 Accessibility of facilities for students and faculty 6.2 Safety and convenience in daily use 6.3 Functionality to support academic, administrative, and institutional activities		

Table 1: *The conceptual framework represents the transformation of data into output*

Statement of the Problem

The existing Civil Engineering building at La Concepcion College, Kaypian, has limitations in space, safety provisions, and facility design, which affect its overall functionality and the quality of services provided to students and faculty. With the increasing demand for adequate space, improved facilities, and enhanced safety measures, there is a clear need to develop a design that addresses these concerns. This study proposes the structural design of a multi-level Civil Engineering building with basement parking and an enclosed gymnasium to provide a safe, functional, and well-equipped environment for academic and institutional activities

This study seeks to address the following research questions:

1. How can the proposed structural system sustain the maximum load capacity considering dead load, live load, wind load, and seismic load in terms of:

    1.1 Compliance with the National Structural Code of the Philippines (NSCP)

    1.2 Stability and factor of safety of beams, columns, slabs, and foundations

    1.3 Overall resistance against structural failure

2. How can the durability and service life of the building materials and structural system be determined in terms of:

    2.1 Resistance to deterioration under environmental exposure

    2.2 Structural performance during seismic conditions

    2.3 Estimated lifespan of the materials used

3. How can the basement parking facility be designed in terms of:

    3.1 Vehicle capacity based on standard parking dimensions

3.2 Circulation flow and accessibility for users

3.3 Safety and security provisions for vehicles and pedestrians

4. How can the allocation of usable floor areas for classrooms, laboratories, and faculty rooms be optimized in terms of:

4.1 Total floor area provided versus required standards

4.2 Comfort and functionality of spaces for learning

4.3 Effective utilization of the available building footprint

5. How can the gymnasium design support institutional activities in terms of:

5.1 Maximum occupancy capacity for academic and recreational functions

5.2 Suitability for sports and student wellness programs

5.3 Accommodation of large-scale school events

6. How can the overall proposed structural design contribute to the Civil Engineering department's development in terms of:

6.1 Accessibility of facilities for students and faculty

6.2 Safety and convenience in daily use

6.3 Functionality to support academic, administrative, and institutional activities

Objective of the Study

This study aims to develop a comprehensive structural design for a multi-level Civil Engineering building with basement parking and an enclosed gymnasium at La Concepcion College, Kaypian, addressing existing limitations in space, safety, and

facility design while improving functionality, accessibility, and overall safety for students and faculty.

Specifically, the objectives of this research are as follows:

1. To design the proposed structural system capable of sustaining maximum load conditions, including dead load, live load, wind load, and seismic load, in terms of:

    1.1 Compliance with the National Structural Code of the Philippines (NSCP)

    1.2 Stability and factor of safety of structural members

    1.3 Resistance against structural failure

2. To evaluate the durability and service life of the building materials and structural systems in terms of:

    2.1 Resistance to deterioration under environmental exposure

    2.2 Structural performance under seismic conditions

    2.3 Estimated material lifespan

3. To design the basement parking facility in terms of:

    3.1 Vehicle capacity based on standard dimensions

    3.2 Circulation flow and accessibility for users

    3.3 Safety and security for vehicles and pedestrians

4. To optimize the allocation of usable floor areas for classrooms, laboratories, and faculty rooms in terms of:

    4.1 Compliance with the required space standards

    4.2 Comfort and functionality of learning spaces

    4.3 Efficient utilization of the building footprint

5. To design the gymnasium in support of the institutional activities in terms of:

    5.1 Maximum occupancy for academic and recreational functions

    5.2 Suitability for sports and wellness programs

    5.3 Accommodation of large-scale school events

6. To assess the contribution of the overall proposed structural design to the development of the Civil Engineering department in terms of:

    6.1 Accessibility of facilities for students and faculty

    6.2 Safety and convenience in daily use

    6.3 Functionality to support academic, administrative, and institutional activities

Hypothesis

H_o: There is no significant difference in the structural design of the proposed multi-level Civil Engineering building with basement parking and gymnasium at La Concepcion College, Kaypian.

H_a: There is a significant difference in the structural design of the proposed multi-level Civil Engineering building with basement parking and gymnasium at La Concepcion College, Kaypian.

Significance of the Study

This study will be undertaken to address the growing need of the La Concepcion College for improved facilities that support the academic and hands-on training of Civil Engineering students. The proposed multi-level building with basement parking and an enclosed gymnasium is designed to provide safe, functional, and modern spaces that will benefit different groups in the institution.

For the **students**, the project will provide classrooms, laboratories, and specialized areas that strengthen both classroom-based learning and practical activities, ensuring a more conducive environment for skill development.

For the **faculty,** the improved facilities will help lessen issues related to limited spaces and resources, allowing them to deliver instruction mote effectively and apply practical concepts in their teaching.

For the **institution**, the proposed design offers a long-term solution to existing issues of limited space, insufficient classrooms, and facilities that need improvement. It will also maximize land use through basement parking and promote student well-being through a gymnasium that supports academic, recreational, and school activities.

For **future researchers and professionals**, this study will serve as a valuable reference for the planning and design of academic buildings that prioritize safety, stability, and durability while complying with the National Structural Code of the Philippines (NSCP) and other engineering standards.

Scope and Limitation of the Study

The scope of this study will cover the structural design of a multi-level Civil Engineering building with basement parking and gymnasium. This research will focus on planning and designing the building's structural components, selecting appropriate construction materials, and ensuring safety, stability, and durability according to the National Structural Code of the Philippines (NSCP) and other relevant standards. The study also aims to support the goal of the school by providing a practical and reliable design that will improve learning and student well-being.

This study is limited to the structural design, basic architectural layout, and associated cost estimates. It does not cover interior design, construction costs, or the actual construction process. Other considerations, such as financial planning beyond the estimated costs, operational management of the school, and long-term maintenance, are not included in the scope of this research. These boundaries are set to maintain focus on the primary objective of producing a safe and reliable structural design intended for academic purposes.

Definition of Terms

Academic functions - Activities directly related to learning and institution, including lectures, laboratory sessions, and workshops.

Accessibility - The ease with which students, faculty, and visitors can reach and use all areas of the building, including considerations for persons with disabilities.

Basement Parking - A parking area located beneath the main floors of the building, intended to maximize space utilization and provide safe and convenient vehicle accommodation.

Capacity - The maximum number of people, classrooms, or vehicles that a facility can safely accommodate.

Civil Engineering Building - The proposed multi-level structure designed to accommodate classrooms, laboratories, faculty offices, and other facilities necessary for Civil Engineering education.

Conducive Learning Environment - A safe, organized, and functional setting that promotes effective learning and teaching.

Design Standards - Established guidelines and regulations that ensures a building is safe, functional, and meets modern engineering requirements.

Durability - The capacity of building materials and structural components to resist deterioration and remain functional over time.

Efficiency - The building's ability to make optimal use of space, resources, and facilities for both academic and institutional purposes.

Functionality - The extent to which the building effectively supports academic,

administrative, and recreational activities.

Gymnasium - A space within the building designated for physical activities, sports, and recreation to support the health and well-being of students and faculty.

Hands-On Activities - Practical exercises, laboratory experiments, or other activities that allow students to apply Civil Engineering concepts in real-world scenarios.

Institutional Activities - School programs and events, such as sports, recreational events, and administrative functions, held within the facility.

National Structural Code of the Philippines (NSCP) - The official set of standards and guidelines for structural design and construction in the Philippines to ensure safety, stability, and durability.

Safety - Features and measures included in the building design to protect students, faculty, staff from accidents, hazards, and injuries.

Stability - The building's ability to maintain its structural integrity and withstand environment and load stresses without risk of collapse.

Structural Design - The process of planning and creating a building's structure to ensure its safety, stability, and durability in accordance with engineering standards.

CHAPTER 2

Review of Related Literature and Studies

This chapter represents a review of related literature and studies, following a thorough search done by local and foreign researchers. Those included in this chapter aid in familiarizing with relevant and related information to the current study.

Foreign Literature

According to Özşahin (2022), designing tall buildings requires cooperation from professionals across different fields because these structures involve complex systems in structure, installation, facade, circulation, and fire safety. Architects must understand both architectural and structural considerations and how they connect. The study reviewed 230 tall buildings in Turkey to identify common patterns. Results showed that most towers used prismatic forms, shear-frame systems, residential functions, single symmetrical central cores, and rectangular floor plans.

According to Nenadović and Milošević (2021), sustainable buildings aim to lower environmental impacts while improving life quality by balancing environmental, economic, and social aspects. Structural design plays a central role and should be treated as part of the larger building system. Their study used an integrative literature review and system theory to evaluate how design supports user benefits during a building's use phase. Key factors include safety, comfort, spatial organization, adaptability, and maintenance. The research produced a conceptual

framework that links structural design to user benefits, helping decision-making and optimization. Findings highlight the need for a systemic approach to structural design to achieve sustainability.

According to Toyokawa (2024), Yoshinobu Ashihara criticized modern architecture and urban planning in his book *Gaibu kūkan no kōsei (Exterior Space in Architecture)* and sought to design plazas suited for human use. The study examines Ashihara's Komazawa Park Gymnasium, built for the 1964 Tokyo Olympics, with focus on its hyperbolic paraboloid shell design, and the Komazawa Central Plaza. It also compares these works with Kenzo Tange's Hiroshima Peace Memorial Park to highlight Ashihara's distinct architectural approach.

According to Muhammad, Orejudos, and Aniñon (2024), bamboo grows rapidly, has strong sustainability indicators, and possesses high strength, but the design of bamboo structures remains limited in practice. Their review analyzed existing studies on structural analysis and design for bamboo and identified significant gaps. These include the absence of design guidelines that address bamboo fiber distribution, lack of load parameters tailored to bamboo structures, insufficient studies on culm connections and connection stiffness, limited types of connections studied, and standards that do not fully account for species-specific properties. The findings emphasize the need for more comprehensive guidelines and standards to support bamboo as a reliable structural material.

According to Acosta (2021), field observations were used to study failure modes of educational facilities, focusing on roof coverings, roof structures, and

exterior windows. A Monte Carlo Simulation modeled an archetype structure by comparing probabilistic resistance capacities with probabilistic wind loads. Damage probabilities were evaluated across three damage states under varying wind speeds. The vulnerability curve was represented with a cumulative probability density function with a mean of 4.7314 and a standard deviation of 0.4061. A case study of Typhoon Nina in 2016 showed that the model underpredicted mean damage ratios by about 13.17 percent at wind speeds of 40.225 m/s, and by 3 to 6 percent at wind speeds between 49 m/s and 71 m/s. Reported government damage data were compared to the model, and a Spearman rank correlation of 0.856 indicated strong positive correlation between predicted and observed damage.

Local Literature

Siman (2023), highlighted the Philippine construction industry as a major contributor to economic growth, infrastructure development, and job creation. In 2022, the industry achieved a 9.2% growth rate, largely driven by the *Build! Build! Build!* Program of former President Rodrigo Duterte. The current administration continues to modernize infrastructure, further boosting construction-related employment, investments, and opportunities. However, the industry's high consumption of raw materials raises environmental concerns, pushing stakeholders toward adopting green construction practices. The study also projected that the Philippines would become the fastest-growing construction market globally, with an estimated 6% annual growth over the next 15 years. Using literature, project documents, memos, and reports as references, the research analyzed industry trends, forecasted its trajectory for the next

five years, and provided recommendations for engineering design firms to adapt to the evolving market.

Boco et al. (2024) explored the architectural styles and structures of the Technological University of the Philippines–Manila to highlight how design influences the institution's visual identity and functionality. Using a qualitative descriptive method, the study analyzed photos of campus landmarks to examine architectural styles, design elements, arrangements, materials, and colors. The findings emphasized the importance of balancing visual appeal with functionality and adaptability in future campus developments to enhance the educational experience. The study concluded that the university's buildings reflect diverse architectural styles, each contributing to its distinct identity and role in fostering creativity, engagement, and well-being within the academic environment. The researchers further recommended broadening the relevance of this work to society by stressing the role of well-designed campuses in improving educational settings.

According to Almonte (2020), rapid urbanization and modernization without sufficient consideration of environmental and future risks contribute significantly to global ecological problems. To address this, a team from Lyceum of the Philippines University–Laguna proposed a two-story sustainable building in Calamba City that meets the Building Research Establishment Environmental Assessment Method (BREEAM) criteria for new construction. The project design incorporates local green resources and advanced software analyses (e.g., CSi) to ensure quality and sustainability. Cost assessments revealed only a 3% difference between conventional

construction and the BREEAM-based project, suggesting that stable, safe, and sustainable construction is financially feasible.

According to Gonzaga (2021), a condition assessment of buildings at the University of Eastern Philippines was conducted to evaluate functionality, serviceability, and non-structural factors as perceived by end users. Using ocular inspections, document reviews, survey questionnaires, and American Concrete Institute (ACI) guidelines, the study identified non-structural cracks across several buildings. The College of Nursing was found to be the most critical in terms of structural concerns, while the College of Science was perceived as the most functional with a rating of 3.07. Findings highlight the need for repair and maintenance, particularly in the College of Nursing, to ensure safety and usability.

According to Martinez (2021), a virtual structural design of a community college in Bukidnon was developed using Virtual Reality (VR) technology to simulate the campus and its buildings. The project applied a modified Iterative Development Model, with TinkerCAD for 3D modeling and Unity for developing the VR environment. Grade 12 students from nearby schools evaluated the VR application using the System Usability Scale, yielding an excellent usability score of 90%. The study demonstrated how VR can provide prospective students with immersive experiences of campus facilities without physically visiting the site.

Foreign Study

According to Jamaludin et al. (2024), car parks are vital in new developments, yet basement car parks face space limitations due to building footprints and structural columns. Their study examined three design aspects: parking aisle networks, building footprint, and column positions. A parking lot placement algorithm combined with a genetic algorithm was used to optimize layouts. Results showed that car park capacity is not strictly tied to aisle perimeter, rectangular footprints allow greater capacity, and adjusting column positions increases available space for parking. The proposed method enables automated design and impact analysis of basement car parks.

According to Fan (2020), the rapid growth of underground parking construction has exposed problems such as low space utilization caused by poor design. The study optimized parking space design by addressing the column network layout, the area occupied by each space, and vehicle parking methods. These improvements aim to increase the efficiency and utilization of underground parking resources.

According to de Lima et al. (2024), a seventeen-story commercial office building was structurally designed and analyzed using a composite system of steel and reinforced concrete. The study applied SAP 2000 software for static and modal analysis. Design work included defining the structural system, construction methods, materials, and load combinations. Steel decking slabs were dimensioned using manufacturer tables, and composite beams were verified during both construction and final stages, with shear connectors considered post-cure. Nonlinear geometric analysis

was applied to steel columns to determine stresses and displacements. Modal analysis showed that the first two vibration modes had frequencies below 1 Hz, confirming structural flexibility under wind actions. Beam-beam and beam-column connections were also designed. The study demonstrates a practical application of composite structural design that supports safety, innovation, and engineering practice.

According to Gupta (2021), structural design is a core part of civil engineering that starts with components such as slabs, beams, columns, and footings. His project focused on analyzing and designing a G+3 reinforced concrete hospital building, 14.90 meters high, located in seismic zone IV. Manual load calculations were performed, and STAAD Pro software was used for structural analysis and design following Limit State Design under Indian Standards. The study evaluated different load combinations and their effects, with bending moment diagrams analyzed in post-processing to assess structural performance.

According to Ahmed et al. (2020), the structural performance of high-rise buildings was evaluated by replacing conventional reinforced concrete (RC) slabs with cross-laminated timber (CLT) slabs. A numerical case study analyzed a 60-story twin-tower RC frame building connected at the top. Three steps were performed: modeling with RC slabs as reference, substituting with CLT slabs, and redesigning the skeleton with CLT for material optimization. Lateral loads relevant to Saudi Arabia were applied, and performance checks included diaphragm strength, lateral resistance, total drift, inter-story drift, base reactions, structural periods, and floor accelerations. The study also compared foundation demands based on weight differences between RC

and CLT slabs. Findings showed that CLT offers material savings while maintaining structural performance under code requirements.

Local Study

According to Baylon et al. (2022), the Philippines is highly exposed to natural hazards such as earthquakes and volcanic activity, making seismic vulnerability assessments crucial, especially in Metro Manila. Their study assessed the seismic hazard vulnerability of the PUP Engineering and Science Research Center to support pre-disaster mitigation and emergency response planning. The methodology was guided by Haseeb Tahir's research on fragility curve databases for multi-hazard performance-based design and Vasavada's damage state thresholds. The tailored procedures provided a framework for evaluating building performance against seismic risks.

According to Jimenez (2024), earthquakes pose serious risks to school buildings, making it vital for these structures to remain operational during and after seismic events. His study assessed the seismic vulnerability of school buildings in Malolos using machine learning combined with rapid visual screening (RVS). Data from the Malaysian RVS were used to build models, and results showed that machine learning tended to overestimate vulnerability compared to traditional RVS. The capacity spectrum method was applied to validate the predictions. The study proposes machine learning as a framework that schools and local authorities can adopt to prioritize resources for strengthening vulnerable schools.

According to Gonzaga (2021), the condition assessment of buildings at the University of Eastern Philippines focused on functionality, serviceability, and non-structural factors. Methods included visual inspection, document review, user surveys, and application of ACI guidelines. Findings showed non-structural cracks across several buildings, with the College of Nursing identified as the most critical in terms of cracking and in need of repair. The College of Science was rated the most functional by end users, with a score of 3.07.

According to Bagang et al. (2023), abandoned shipping containers were proposed for constructing a three-story academic building at Don Honorio Ventura State University Apalit Campus to address rising student enrollment while promoting sustainability. Using STAAD v8i, the design demonstrated that container-based structures are durable and capable of withstanding calamities. The inclusion of solar panels provided a sustainable power source and ensured reliability during emergencies. The study highlighted the feasibility of container vans as building materials and presented a model for sustainable and smart academic building construction.

Elias et al. (2022) emphasized the importance of investing in higher education as a means of developing human capital, especially in newly converted universities. Their study assessed the status of a university to identify areas for improvement in instruction and physical plant development. The research focused on curricular offerings, student demographics, faculty qualifications, non-teaching employees, and physical facilities. Data were gathered through documentary review of system-

generated records, HRMO files, and planning office inventories, then analyzed using frequency and percentage. The study concluded that adequate resourcesphysical, human, and financial—are crucial to the success of a school system. Provision of quality buildings and facilities for both staff and students is essential in achieving effective teaching and learning outcomes.

Synthesis of Review in Related Literature and Studies

Foreign and local studies highlight gaps in structural design, sustainability, and safety. Researchers stress the need for coordination across design fields. Özşahin (2022) found that tall buildings often use prismatic forms and central cores. Nenadović and Milošević (2021) linked structural systems to user safety and comfort. Bamboo and CLT offer alternatives to concrete but lack clear standards. Ahmed et al. (2020) showed CLT maintains performance while reducing weight. Parking studies by Jamaludin et al. (2024) and Fan (2020) improved space use through layout algorithms. Acosta (2021) used simulation to match typhoon damage forecasts with real-world data.

Philippine studies respond to local risks and growth. Siman (2023) reported 9.2 percent growth in construction due to infrastructure programs. Almonte (2020) designed a sustainable building with only 3 percent cost difference from conventional projects. Gonzaga (2021) found critical cracks in school buildings. Jimenez (2024) used machine learning to assess earthquake risk. Bagang et al. (2023) proposed container schools with solar panels. Martinez (2021) showed that VR helps users

explore school designs. Local and foreign work both call for design that meets structural demands, improves user outcomes, and supports long-term use.

CHAPTER 3

Research Methodology

This chapter concentrates on the discussion of the research method and procedures adhered to by the researcher to answer systematically the study of experimental research. Specifically, the research design, respondents of the study, sampling techniques, instruments used with its construction, validation, administration and retrieval, and the statistical treatment of data used for the accurate data analysis and interpretation were explained in this chapter.

Research Design

This is a Descriptive Quantitative approach that will enable the collection of numerical data, which may be statistically analyzed to identify trends and patterns. It focuses on applying engineering codes and methods to develop a structural design for a multi-level Civil Engineering building with basement parking and gymnasium. The design process relies on numerical data, load calculations, and software simulations. Results are compared against standards to ensure safety, stability, and compliance.

Design Process

Conceptualization

The design follows the National Structural Code of the Philippines (NSCP) and other relevant standards. These codes guide safety, stability, durability, and

accessibility. The building layout considers classroom and laboratory requirements, parking capacity, and gymnasium needs.

Site Analysis

The site of La Concepcion College in Kaypian is assessed based on space availability, accessibility, soil conditions, and environmental impact. Factors such as vehicle circulation, and space utilization are considered. The analysis ensures that the building will function well within the school setting.

User Needs

The design responds to the needs of students, faculty, and the institution. Classrooms, laboratories, and faculty rooms are planned to meet academic requirements. The gymnasium supports both physical and school-wide activities. Basement parking addresses congestion and maximizes limited land area.

Design Tools and Software

AutoCAD is used for architectural layouts and 2D floor plans. SAP2000 and STAAD Pro are applied for structural analysis and design of beams, slabs, columns, and foundations. SketchUp or Revit provides 3D visualization for better presentation and validation of layouts. Excel is used for detailed load calculations and cost estimates.

Sample and Population

The study focuses on facilities for Civil Engineering students and faculty of La Concepcion College. It also considers institutional needs for classrooms, laboratories, and school events. The proposed building serves as the sample for structural design application.

Sampling Technique

Purposive sampling is used in this study. The participants are Civil Engineering students, faculty, and administrators of La Concepcion College. These groups represent the primary users of the proposed building. Their input helps identify the requirements for classrooms, laboratories, faculty spaces, parking, and gymnasium. This technique ensures that data is taken from individuals directly affected by the design. It avoids unrelated responses and focuses on the real needs of the building users.

Research Instrument

In this study, the following instruments are used to gather the data needed for the design and evaluation of the proposed building.

A. Designing

2D and 3D models are created to present accurate layouts and visualizations. AutoCAD is used for plans and sections, while SketchUp provides 3D views for spatial understanding.

B. Surveys

Structured questionnaires are distributed to Civil Engineering students, faculty, and administrators. The survey collects feedback on classroom requirements, laboratory needs, faculty spaces, gymnasium use, and parking concerns.

C. STAAD and SAP2000

Structural analysis software is used to test the strength and stability of beams, slabs, columns, and foundations. Load combinations, including dead load, live load, wind load, and seismic load, are created in compliance with the National Structural Code of the Philippines (NSCP).

D. Miniature Model

A scaled-down model of the proposed building is prepared. It serves as a visual and physical representation that demonstrates the overall form, layout, and basic structural concept of the design.

Data Gathering

The data collection involves four components: surveys, structural design work, miniature modelling, and costing.

The survey gathers input from Civil Engineering students, faculty, and administrators of La Concepcion College. Survey questionnaire is prepared for clarity and reliability. Respondents provide feedback on classroom needs, laboratory requirements, parking issues, and gymnasium use. Surveys are conducted in person within the college to ensure accuracy and direct clarification of responses.

The structural design work collects technical data for analysis. Architectural requirements are translated into floor plans using AutoCAD. Load data, including dead load, live load, wind load, and seismic load, are calculated following the National Structural Code of the Philippines (NSCP). SAP2000, STAAD Pro and manual calculation are used to model and analyze beams, columns, slabs, and foundations. Results are validated against code requirements for safety and stability.

The miniature model is prepared as a scaled representation of the proposed building. It demonstrates the physical form, floor layout, and structural concept in a tangible way that supports visualization and presentation.

Costing is conducted to determine financial feasibility. Excel is used to organize material quantities, labor rates, and construction expenses. This step ensures that the proposed design is structurally sound and economically practical.

Statistical Tool

Percentage and Frequency Distribution

This method is used to present the demographic profile of respondents. It shows the number of individuals (frequency) in each category, such as gender, age group, and residency status. Percentage values indicate the proportion of each category relative to the total sample size. This approach highlights trends and patterns in respondent characteristics.

Chi-Square Test

The Chi-square test is applied to determine if there are significant relationships or differences between categorical variables. It provides a statistical basis for analyzing survey data and supports validation of results.

Likert Scale and Weighted Mean

The Likert scale is used to measure the perceptions and opinions of respondents regarding the proposed Civil Engineering building. Questions focus on functionality, accessibility, safety, and adequacy of spaces such as classrooms, laboratories, faculty rooms, gymnasium, and parking.

Rate	Verbal Interpretation	Range
5	Strongly Agree	4.20 – 5.00
4	Agree	3.40 – 4.19
3	Neutral	2.60 – 3.39
2	Disagree	1.80 – 2.59
1	Strongly Disagree	1.00 – 1.79

Figure 3 Likert Scale

Formula:

$$Weighted\ Mean\ = \frac{\sum(f\ \times\ w\ )}{Total\ Response}$$

where:

f = frequency of each response

w = weight assigned to each response

VALIDATION LETTER

Dear Engineers,

We hope this letter finds you well.

We are fourth-year civil engineering students from La Concepcion College. We are writing to respectfully request your assistance in **validating our thesis paper** entitled **"Structural Design of a Multi-Level Civil Engineering Building with Basement Parking and Gymnasium at La Concepcion College, Kaypian.**

As part of the academic requirements for thesis completion, we are seeking validation from professionals in the field to ensure that our study is technically sound, relevant, and aligned with current engineering practices. Given your expertise and background in the field, your insights and validation would be of great value to our research.

Thank you very much for considering this request. Your support and guidance would be greatly appreciated as we complete this important academic achievement.

Sincerely,

Researchers:

BLASCO, RUSSEL CHRISTIAN R. **CANDAZA, JEWEL C.**

MALASMAS, DANNA DAISY M. **RUBIS, JENICE N.**

Noted by:

ENGR. ELOISA P. CADAG, MACT
Research Adviser

ENGR. MATTHEW B. PAREDES **ENGR. ELOISA P. CADAG** **ENGR. JAYSON A. TOMAS**
Validator Validator Validator

CERTIFICATE OF VALIDATION

This is to certify that the research questionnaire of the study entitled **"Structural Design of Multi − Level Civil Engineering Building with Basement Parking and Gymnasium"** prepared by Russel Christian R. Blasco, Jewel C. Candaza, Danna Daisy M. Malasmas, and Jenice N. Rubis from Bachelor of Science in Civil Engineering students of La Concepcion College has been validated by the undersigned experts to ensure that the items are clear, relevant, and appropriate to the study′s objectives.

After careful review, the panel of validators find the questionnaire valid and suitable for data gathering process.

Noted by:

ENGR. ELOISA P. CADAG, MACT
Research Adviser

Validated by:

ENGR. MATTHEW B. PAREDES	**ENGR. ELOISA P. CADAG**	**ENGR. JAYSON A. TOMAS**
Validator	Validator	Validator

QUESTIONNAIRES

Dear Respondents,

We are fourth-year Civil Engineering students from La Concepcion College, currently enrolled in Research Writing. We kindly ask for your cooperation in answering our survey questionnaire, which aims to gather your insights and reactions related to our study. Please be assured that all the information you provide will be treated with the utmost confidentiality and used solely for academic purposes.

Thank you very much for your time and participation.

Instruction: Kindly put a check mark (✓) in the box beside the statement that best describes your answer.

I. DEMOGRAPHIC PROFILE

Name (optional):

Age

☐ 15 - 18

☐ 19 - 21

☐ 22 - above

Sex

☐ Male

☐ Female

Are you a Civil Engineering student of La Concepcion College, Kaypian?

☐ Yes

☐ No *(If No, please indicate your course:*

_____*)*

II. QUESTIONNAIRE

1. Do you use the school parking facility?

☐ Yes

☐ No *(If No, please skip to Question 12)*

2. How often do you use the parking facility?

☐ Daily

☐ Weekly

☐ Occasionally

3. What type of vehicle do you use?

☐ Car

☐ Motorcycle

☐ Bicycle

☐ E-bike

☐ Scooter

☐ Others (please specify)

4. What time do you usually park your vehicle?

☐ Before 7:00 AM

☐ 7:00 AM to 9:00 AM

☐ 9:00 AM to 12:00 PM

☐ 12:00 PM to 3:00 PM

☐ 3:00 PM onwards

5. What time do you usually leave the parking facility?

☐ Before 12:00 PM

☐ 12:00 PM to 3:00 PM

☐ 3:00 PM to 6:00 PM

☐ 6:00 PM onwards

6. How satisfied are you with the current parking space?

☐ Satisfied

☐ Neutral

☐ Unsatisfied

☐ If unsatisfied, what is the main reason?

☐ Limited parking space

☐ Poor accessibility

☐ Safety concerns

☐ High congestion

☐ Other (please specify)

7. Do you agree to have a new 3-storey engineering building on campus?

☐ Strongly Disagree

☐ Disagree

☐ Neutral

☐ Agree

☐ Strongly Agree

8. Do you agree to include classrooms in the new building?

☐ Strongly Disagree

☐ Disagree

☐ Neutral

☐ Agree

☐ Strongly Agree

9. Do you agree to include laboratories in the new building?

☐ Strongly Disagree

☐ Disagree

☐ Neutral

☐ Agree

☐ Strongly Agree

10. Do you agree to include faculty spaces in the building?

☐ Strongly Disagree

☐ Disagree

☐ Neutral

☐ Agree

☐ Strongly Agree

11. Do you agree to include a gymnasium in the new building?

☐ Strongly Disagree

☐ Disagree

☐ Neutral

☐ Agree

☐ Strongly Agree

12. Do you agree to include a basement parking facility in the new building?

☐ Strongly Disagree

☐ Disagree

☐ Neutral

☐ Agree

☐ Strongly Agree

13. Do you believe the new building will improve accessibility for students and staff?

☐ Strongly Disagree

☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly Agree

14. Do you believe the new building will improve your learning experience?

☐ Strongly Disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly Agree

15. Do you support the construction of the new building if it replaces older facilities?

☐ Strongly Disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly Agree

16. Do you support the construction of the new building if it requires temporary changes to campus traffic or parking?

☐ Strongly Disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly Agree

LEGENDS:	**5** - Strongly Agree	**4** - Agree	**3** - Neutral	**2** - Disagree	**1** - Strongly Disagree

17. Is the durability and service of the building materials and structural system adequate in terms of:

	5	4	3	2	1
Resistance to wear and tear					
Weather resistance					
Maintenance requirements					
Compliance with safety standards					

18. Is the basement parking facility designed effectively in terms of:

	5	4	3	2	1
Space efficiency					
Traffic flow					
Ventilation					
Drainage and flood protection					
Accessibility for persons with disabilities					

19. Is the allocation of usable floor areas for classrooms, laboratories, and faculty rooms optimized in terms of:

	5	4	3	2	1
Space utilization					
Accessibility					
Safety and comfort					
Compliance with building codes					

20. Does the gymnasium design support institutional activities in terms of:

	5	4	3	2	1
Space capacity					
Structural safety					
Accessibility					
Lighting and ventilation					
Adaptability for multiple events					

21. Does the overall proposed structural design contribute to the Civil Engineering department's development in terms of:

	5	4	3	2	1
Support for academic programs					
Research and innovation facilities					
Safety and resilience					
Accessibility and sustainability					